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Method for Generating Process Heat and/or Electrical Energy

This invention relates to a method for generating process heat and/or electrical energy for a machine for the production and/or finishing of a fibrous web, particularly a paper web or paperboard web.

The process heat for paper machines was produced hitherto by combustion of fossil fuels or waste products. The electrical energy for paper machines was produced in distant power stations.

The object of the present invention is to create an improved method of the type initially referred to. In particular the use of renewable energies and/or alternative fuels should also be possible.

This object is accomplished in accordance with the invention in that gas with the highest possible proportion of hydrogen is generated from the waste products resulting during the production and/or finishing of the fibrous web, and this hydrogen-rich gas is used for generating the necessary process heat and/or the necessary electrical energy.

By virtue of this aspect of the invention, in particular renewable energies and/or alternative fuels can be used as well, in which case particularly the waste products from the machine contributing to or the paper machine involved in the production and/or finishing of a fibrous web can

be put to sensible use. Furthermore, a decentralized generation of energy is now also possible.

Particularly bark, fibers, edge cuttings and/or the like can be used as waste products.

The waste products used can also be transformed into methanol first. Alternatively or in addition to this, the use particularly of a so-called DMFC (Direct Methanol Fuel Cell) is also conceivable.

According to a preferred practical aspect of the method according to the invention the waste products used are first conveyed to a reformer. In this case the hydrogen carbons of the waste products used can be transformed into a hydrogen-rich and carbon monoxide-rich gas by means of the reformer, for example through autothermic reforming, partial oxidation or vapor reforming.

To transform the carbon monoxide into another hydrogen-rich gas, the reformer can be followed by one or more shift stages.

It is also an advantage particularly if the reformer or the shift stage is followed by at least one more process stage for further reduction of the carbon monoxide.

According to an expedient practical embodiment the reformer is followed by a stage for pressure swing adsorption. Alternatively or in addition to this, the reformer can also be followed, for example, by a stage for selective oxidation as a further process stage.

Should the waste products resulting during the production and/or finishing of the fibrous web not be sufficient to meet the energy requirement, additional hydrogen carbons and/or additional H_2 can be fed to the reformer. In this case it is conceivable, for example, to supply additional hydrogen carbons in the form of natural gas, biomass, wood chips and/or the like. If H_2 is available, meaning if there is an H_2 grid for example, particularly H_2 can be supplied in addition as already mentioned.

The process heat and/or electrical energy is preferably generated in each case at that point of the machine at which it is required. In other words, the process heat and/or the electrical energy can be generated in each case on, in or near the particular unit of the machine which is to be heated or supplied with electrical energy.

It is an advantage for the process heat and/or electrical energy to be generated by a fuel cell from the acquired hydrogèn-rich gas and/or from additional hydrogen taken from a grid or tank for example. It is preferred for the process heat to be generated by preferably combusting the acquired hydrogen or methanol and/or additional hydrogen taken from a grid or tank for example.

The invention will be described in more detail in the following text using exemplary embodiments and with reference to the drawing, in which:

figure 1	is a chart of the transformation of biomass (hydrogen carbons) into hydrogen (H_2) and
figure 2	is a process chart of the generation of process heat and/or electrical energy for a machine for the production and/or finishing of a fibrous web.

An advantageous embodiment of the method according to the invention for the generation of process heat and/or electrical energy for a machine for the production and/or finishing of a fibrous web, particularly a paper web or paperbard web, is described in the following text with reference to figures 1 and 2 purely by way of example. Hence the machine in question can be, for example, a paper machine including an upstream stock preparation section and any units for finishing the fibrous web or paper web.

To begin with, gas with the highest possible proportion of hydrogen is generated from the waste products resulting during the production and/or finishing of the fibrous web. This hydrogen-rich gas is then used to generate the necessary process heat and/or the necessary electrical energy.

The waste materials can be, for example, bark, fibers of no use for the subsequent production process, edge cuttings and/or the like, meaning biomass or hydrogen carbons in the general sense. Apart from biomass, particularly the use of natural gas, alcohols and/or the like is conceivable.

The waste products used can also be transformed into methanol first.

Figure 2 shows a chart of the transformation of biomass (hydrogen carbons) into hydrogen (H_2), whereby apart from biomass the use of, for example, natural gas, alcohols and/or the like is also possible.

As is evident in the diagram in figure 2, biomass or the waste products used can be fed first to a reformer 10. By means of this reformer 10 the hydrogen carbons concerned (C_nH_m) are transformed into a hydrogen-rich

gas and a carbon monoxide-rich gas. For this purpose, air as well as the hydrogen carbons C_nH_m are fed to the reformer 10. In the case of autothermic reforming and vapor reforming, water is supplied in addition. In the case of partial oxidation, only air is supplied. Through the upstream operation of the reformer 10 the respective energy carrier (e.g. biomass) can be transformed by combustion into hydrogen or a hydrogen-rich gas. In the case under consideration, for example, this takes place at a temperature of around 800°C.

The hydrogen carbons C_nH_m of the biomass or waste products used can be transformed into a hydrogen-rich and carbon monoxide-rich gas by means of the reformer 10, for example through autothermic reforming, partial oxidation or vapor reforming. To transform the carbon monoxide into another hydrogen-rich gas, the reformer 10 can be followed by a shift stage 12.

In the case under consideration there follows, for example, a vapor reforming stage in which hydrogen is obtained from hydrogen carbons C_nH_m in two steps. In the first step the hydrogen carbon C_nH_m is first transformed in the reformer 10 into a hydrogen-rich gas and a carbon monoxide-rich gas. The resulting carbon monoxide (CO) is then separated off and mixed in the second step, i.e. in shift stage 12, with water or steam to create another hydrogen fraction. The applicable reaction equation is as follows:

$$CO + H_2O \rightarrow CO_2 + H_2.$$

H_2 and CO are not separated therefore. CO and H_2O react "selectively" with each other.

The reformer 10 or the shift stage 12 can be followed by at least one more process stage for further reduction of the carbon monoxide.

In this case the reformer 10 or the shift stage 12 can be followed, for example, by a stage 14 for pressure swing adsorption and/or a stage 16 for selective oxidation as a further process stage.

The stage for pressure swing adsorption (PSA) can comprise in particular the following steps:

- adsorption at high pressure
- pressure decrease
- flushing with product gas at low pressure
- pressure increase with untreated gas or product gas

In the case of selective CO oxidation (stage 16) the carbon monoxide can be oxidized selectively to CO_2 through the supply of oxygen or air and the help of a catalyst. The hydrogen content of the synthesis gas is at least largely retained thereby.

Should the waste products resulting during the production and/or finishing of the fibrous web not be sufficient to meet the energy requirement, additional hydrogen carbons can be supplied to the reformer 10. In this case these additional hydrogen carbons can be supplied to the reformer 10 in the form of, for example, natural gas, biomass, wood chips and/or the like.

The process heat and/or electrical energy is preferably generated in each case at that point of the machine at which it is required. In other words, the process heat and/or the electrical energy can be generated in each

case on, in or near the particular unit of the machine which is to be heated or supplied with electrical energy.

As is evident in figure 2, the process heat and/or electrical energy can be generated in particular by means of at least one fuel cell 18 from the acquired hydrogen-rich gas. Hence the process heat is preferably generated by combustion of the acquired hydrogen or methanol.

Figure 2 shows a process chart of the generation of process heat or electrical energy for a paper machine 20 which is fed with wood, fibers and/or the like and delivers the paper 10.

As is again evident in this process chart, the waste or biomass resulting in the paper machine 20 is fed to a reformer 10. In the case under consideration, this reformer 10 is fed in addition with natural gas

The hydrogen H_2 acquired via the reformer 10 is fed on the one hand directly to the paper machine 20 as fuel. On the other hand, hydrogen H_2 generated by the reformer 10 is fed to at least one fuel cell 18, which in the case under consideration delivers both process heat and electrical energy for the paper machine 20.

List of reference numerals

10	Reformer
12	Shift stage
14	Stage for pressure swing adsorption
16	Stage for selective oxidation
18	Fuel cell
20	Paper machine